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APPLICATION OF EFFICIENT SFHA AND TLBO ALGORITHMS FOR CELL FORMATION PROBLEMS IN CELLULAR MANUFACTURING ENVIRONMENT

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ABSTRACT

Cellular Manufacturing (CM) is a basic Group Technology (GT) application that has been utilized in a few true modern applications. The issue of cell arrangement is considered as the principal most critical criteria in the design of Cellular Manufacturing Systems (CMS), so as to limit lead time and setup time to amplify productivity and profitability. In this paper, an efficient Sheep Flock Heredity algorithm (SFHA) and another proficient optimization technique, called Teaching–Learning-Based Optimization (TLBO) are discussed for the advancement of cellular manufacturing issues. That simple genetic algorithm SFHA is referred as multi-level genetic operations, which can obtain good solutions. SFHA algorithm was generally based on the natural change of sheep in the flock. The procedure of Teaching Learning Based Optimization is partitioned into two sections: the initial segment comprises of 'Teacher Phase' and the second part comprises of the 'Learner Phase'. 'Teacher Phase' implies gaining knowledge from the teacher and 'Learner Phase' implies learning by the communication among learners. So in this paper, the main aim is applying SFHA & TLBO algorithms for Cell Formation problems in Cellular Manufacturing Environment. Graphical User Interface (GUI) is developed for both SFHA and TLBO algorithms to solve any size of Cell Formation problem within fraction of seconds to obtain cells with number of Exceptional Elements and Grouping Efficacy.

KEYWORDS: Group Technology, Cellular Manufacturing, Exceptional Elements & Grouping Efficacy

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Original Article

1. INTRODUCTION

Group Technology (GT) is a manufacturing philosophy that examines, decides and allots parts, which are to be made, into a lot of part families and allocates the machines into a various cells. CMS is depends on the GT idea that is recognized as a procedure for improving productivity and to be progressively effective underway firms by lessening the setup times, lead times, working in process lot sizes, throughput times, material handling costs, tooling cost, labor cost and production equipment cost. Cell formation, intra cell machine format and cell layout design are three fundamental and essential strides in design of CMS. Cell Formation problem (CFP) is also called part machine gathering problem, which is characterized as grouping the parts into part families and to comparing machine cells. GT bunches parts into families and machines into groups so a group of parts can be delivered within a group of machines. The problem of deciding part families and machine groups is known as the Cell Formation, CF problem.

Firstly, SFHA is proposed and used by Nara, K., Takeyama, T., & Kim, H. [1]. In a research paper by Chandramouli Anandaraman, Arunvikram, Madurai Sankarand and Ramaraj Natarajan [2] one can get some basic idea about scheduling optimization using two different algorithms one among is SFHA, which has been concluded stating SFHA shows best results. By doing modification in the conventional SHFA, there are two referred articles published by G. Vijay Chakaravarthy, S. Marimuthu, S.G. Ponnambalam and G. Kanagaraj [3] and G. Vijaychakaravarthy, S. Marimuthu, A. Naveen Sait [4]. TLBO is an algorithm [5] which can be used for many approaches, here we have using it for formations of cells. Here, the TLBO [6] is generally divided into 2 phases, first phase is called Teachers Phase and the other phase is called the Learners Phase. In the beginning, we form the cells of the required parts and machines in a random order. A text book Innovative Computational Intelligence A Rough Guide to 134 Clever Algorithms [7] was referred to know about both algorithms and another text book Operations Management Research and Cellular Manufacturing Systems [8] is also referred for details of Problem sets.

2. STEPWISE ALGORITHM IMPLEMENTATION TO CELL FORMATION PROBLEMS

2.1 Steps in SFHA

The Algorithm implementation steps are mentioned in detail below and applied to a (5x7) Problem shown below.

Problem Source: J. R. King, V. Nakornchai (1982)

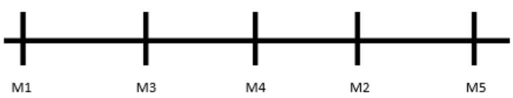
Problem Size: (5 Machines × 7 Parts)

Problem Data Set:

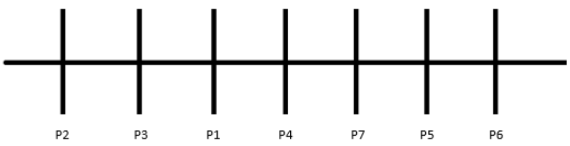
Table 1

M/P	Part 1	Part 2	Part 3	Part 4	Part 5	Part 6	Part 7
Machine 1	0	1	0	1	1	1	0
Machine 2	1	0	1	0	0	0	0
Machine 3	1	0	1	0	0	1	1
Machine 4	0	1	0	1	0	1	0
Machine 5	1	0	0	0	1	0	1

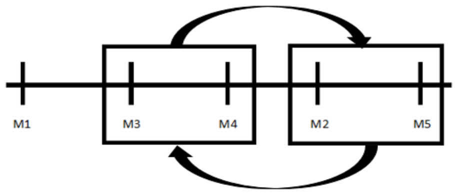
Step 1: Generating a random Machine sequence.



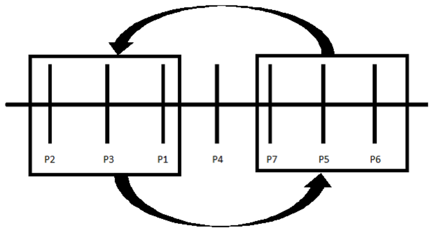
Step 2: Similarly a random Part sequence is also generated after machines are randomized.



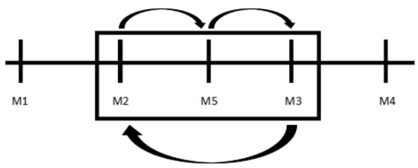
Step 3: Performing Sub Chromosomal Crossover on above generated Machine sequence.



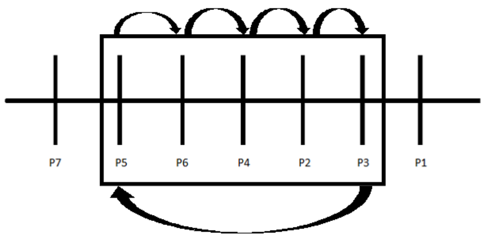
Step 4: Similarly Sub Chromosomal Crossover is performed for random Part sequence generated.



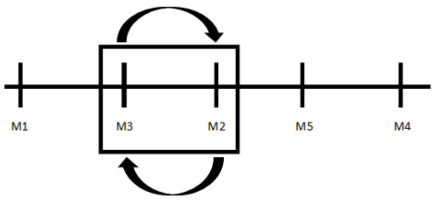
Step 5: Performing Inverse Mutation on the above obtained Machine sequence.



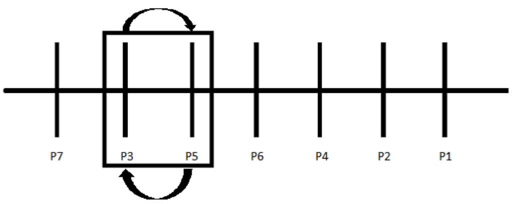
Step 6: Similarly Inverse Mutation on the above obtained Part sequence.



Step 7: Performing Pair-Wise Mutation for the above obtained Machine sequence.



Step 8: Similarly Pair-Wise Mutation for the above obtained Part sequence.

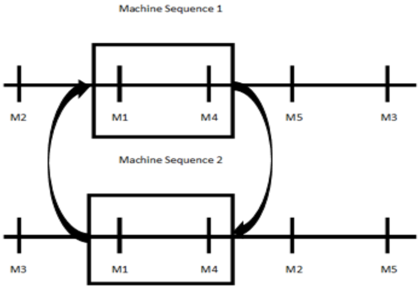


Solution Obtained After Applying Step 1 to Step 8

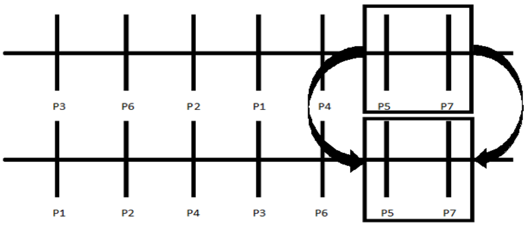
Table 2

M/P	Part 7	Part 5	Part 3	Part 6	Part 4	Part 2	Part 1
Machine1	0	1	0	1	1	1	0
Machine2	0	0	1	0	0	0	1
Machine3	1	0	1	1	0	0	1
Machine5	1	1	0	0	0	0	1
Machine4	0	0	0	1	1	1	0

Step 9: Now two random sequences are generated and Chromosomal Crossover process is done for the Machines.



Step 10: Similarly two random Part sequences are generated and Chromosomal Crossover process is done.



Step 11: As specified in step 5, apply Inverse Mutation for both Machine and Part Sequence obtained in previous step.

Step 12: As given in step 7, apply Pair-Wise Mutation for both Machine and part Sequence obtained from the previous step.

Solution Obtained by using Proposed Sheep Flock Heredity Algorithm is mentioned below and voids (0's) are eliminated here.

Table 3

M/P	Part 3	Part 7	Part 1	Part 5	Part 4	Part 6	Part 2
Machine 2	1		1				
Machine 5		1	1	1			
Machine 3	1	1	1			1	
Machine 4					1	1	1
Machine 1				1	1	1	1

Cells formed along with machine and parts data shown below

Table 4

	Machines	Parts
Cell-1	2,5,3	3,7,1
Cell-2	4,1	5,4,6,2

Number of Exceptional Elements are 2.

2.2 Steps in TLBO

The Algorithm implementation steps are mentioned in detail below and applied to a (5x7) Problem shown below.

Problem Source: J. R. King, V. Nakornchai (1982)

Problem Size: (5 Machines × 7 Parts)

Problem Data Set:

Table 5

M/P	Part 1	Part 2	Part 3	Part 4	Part 5	Part 6	Part 7
Machine 1	0	1	0	1	1	1	0
Machine 2	1	0	1	0	0	0	0
Machine 3	1	0	1	0	0	1	1
Machine 4	0	1	0	1	0	1	0
Machine 5	1	0	0	0	1	0	1

Step 1

Initialize the optimization parameters and define the problem

- Initialize the population = Population is considered to be double the value of number of parts in the problem
- Number of generations required =10
- Optimization Problem = Minimize number of exceptional Elements
- Teaching Factor = 1 or 2
- Random value = consider between 0 to 1

Step 2

Produce the initial population

The initial population is developed depend on size of population. The initial population is generated using randomize () and rand () predefined functions.

Step 3

Teachers Phase

The average of the population is calculated and next step is teacher tries to move the average using the equation

$$Difference\ Average_a = o_i(Y_{new} - (T.F)Y_b$$

Calculated value is included to the present population to refresh its values by below expression

$$Teaching\ Factor = round\ [1 + rand(0{,}1)]$$

Next step is to replace the old solutions with new solutions that gave best results.

By taking Teaching-Factor as 2 & random value as 0.667, Solution obtained using Teachers phase is

Table 6

M/P	7	3	1	6	5	4	2
5	1	0	1	0	1	0	0
3	1	1	1	1	0	0	0
2	0	1	1	0	0	0	0
1	0	0	0	1	1	1	1
4	0	0	0	1	0	1	1

Step 4

Learners Phase

Here, the Learners improve their skills by having a mutual talk with their fiends which makes the more intelligent. Here, in this total learners, teacher selects two students name them as ‘a’ and ‘b’ and the new population is calculated by the equation

$$if(Y_a < Y_b)$$

$$Y_{new} = Y_{old} + o_a(Y_b - Y_a)$$

$$if(Y_a > Y_b)$$

$$Y_{new} = Y_{old} + o_a(Y_a - Y_b)$$

The next step is similar to teachers phase. Replace the old solutions with new solutions which gave a best value.

Solution obtained using Learners phase is

Table 7

M/P	3	7	1	6	5	4	2
2	1	0	1	0	0	0	0
3	1	1	1	1	0	0	0
5	0	1	1	0	1	0	0
4	0	0	0	1	0	1	1
1	0	0	0	1	1	1	1

Step 5

Termination criterion

Repeat step 3 and 4 until the termination criteria is fulfilled and note all optimum solutions obtained.

Cells formed along with machine and parts data shown below

Table 8

	Machines	Parts
Cell-1	2,3,5	3,7,1
Cell-2	4,1	6,5,4,2

Number of Exceptional Elements are 2.

3. CELL FORMATION PROBLEMS SOLVED USING GUI

For both SFHA and TLBO, Java CODE is programmed and Graphical User Interface (GUI) is developed to solve any size of CF within fraction of seconds, which in turn minimizes total computation time.

3.1 Using SFHA

Problem Source: Mosier and Taube (1985)

Problem Size: (10 Machines × 10 Parts)

Problem Data Set:

Table 9

		Parts									
		1	2	3	4	5	6	7	8	9	10
M/c	1	1	0	0	0	0	0	0	0	0	1
	2	0	0	1	1	0	0	0	1	0	0
	3	0	0	0	0	1	1	0	0	0	0
	4	1	0	0	0	0	0	0	0	0	0
	5	0	0	0	0	0	0	1	0	0	1
	6	1	0	0	0	0	0	1	0	0	1
	7	0	0	1	0	0	0	0	1	0	0
	8	0	0	0	0	0	1	0	0	1	0
	9	0	1	1	1	0	0	0	0	0	0
	10	0	1	1	1	0	0	0	1	0	0

For given (10x10) Problem for 10 iterations, 10 machine sequences and 10 part sequences are generated with number of Exceptional Elements and Grouping Efficacy automatically using GUI.

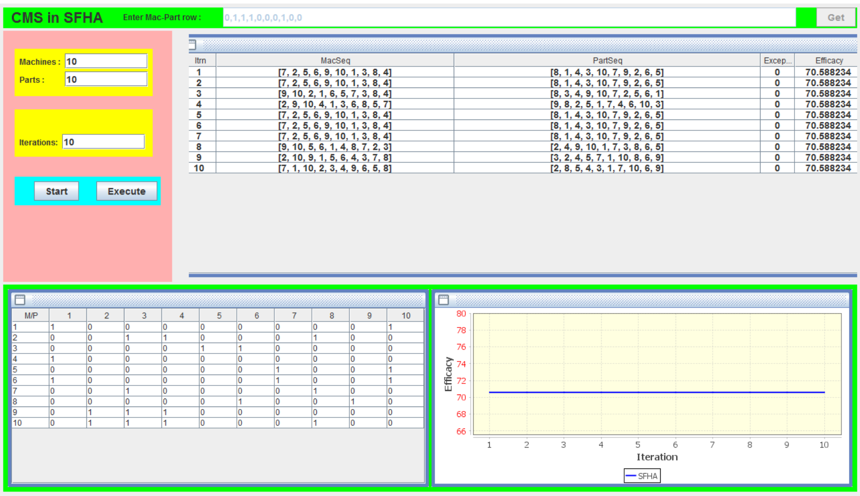


Figure 1: Solution Obtained in GUI Developed using SFHA for (10x10) Problem

M/c \ Parts	2	3	4	8	5	6	9	1	7	10
2		1	1	1						
7		1		1						
9	1	1	1	1						
10	1	1	1							
3					1	1				
8						1	1			
1								1		1
4								1		
5									1	1
6								1	1	1

Figure 2: Block Diagonal Form Obtained for (10x10) Problem using SFHA

3.2 Using TLBO

Problem Source: Kusiak and Chow (1992)

Problem Size: (6 Machines × 8 Parts)

Problem Data Set:

Table 10

M/c \ Parts	1	2	3	4	5	6	7	8
1	0	1	0	1	0	0	1	0
2	1	1	1	0	1	1	1	1
3	0	0	1	0	0	1	0	1
4	0	0	0	1	0	0	1	0
5	1	0	1	0	1	1	0	1
6	0	0	0	1	0	0	1	0

For given (6x8) Problem for 10 iterations, 10 machine sequences and 10 part sequences are generated with number of Exceptional Elements and Grouping Efficacy, automatically using GUI with Teaching-Factor as 2 & random value as 0.667.

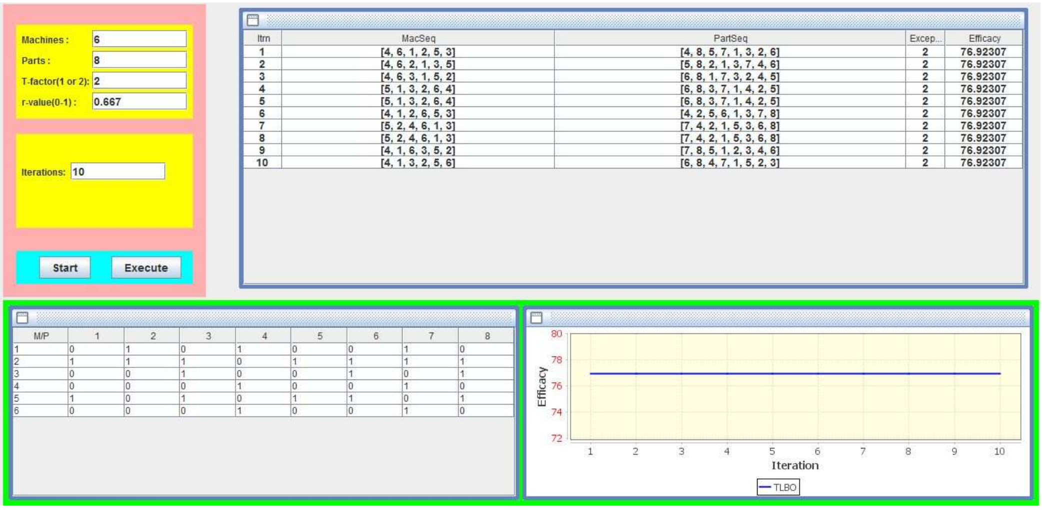


Figure 3: Solution Obtained in GUI Developed using TLBO for (6x8) Problem

		Parts							
		1	2	3	5	6	8	4	7
M/c	2	1	1	1	1	1	1		1
	3			1		1	1		
	5	1		1	1	1	1		
	1		1					1	1
	4							1	1
	6							1	1

Figure 4: Block Diagonal Form Obtained for (6x8) Problem using TLBO

4. CONCLUSIONS

In this paper, machine and part cells are acquired for cell formation problems utilizing Sheep Flock Heredity Algorithm and Teacher Learner Based Optimization Algorithm, to limit total exceptional elements outside the cells and increase Grouping Efficacy. These SFHA and TLBO algorithms yield a better solution in cell formation applications to maximize production rate and to minimize manufacturing lead time in real time applications. Graphical User Interface (GUI) is developed for both SFHA and TLBO algorithms to solve any size of Cell Formation problem within fraction of seconds, to obtain cells with number of Exceptional Elements and Grouping Efficacy to save computational time.

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